Hints on Configuring VAX* Systems for UNIX†
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ABSTRACT

This document reflects our experiences and opinions in configuring four existing VAXes and two more that are on order to run UNIX†.

Our prime considerations in choosing equipment are:

- Cost
- Reliability
- Maintainability and Maintenance Cost
- Delivery Time
- Redundancy of the system

We consider components individually and then describe several system packages built from these components, emphasizing independently single-source systems, minimization of cost, and maximal expansion capability.

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DISCLAIMER

This documents reflects our *personal opinions*. We are responsible for software and hardware support of VAX systems, and the recommendations we give reflect what we would do. We are careful to note the equipment that we recommend but are not using; we recommend no second-vendor equipment that is not known to be in use successfully at several UNIX sites. In any case you may get a lemon, no matter what you buy. All we promise is that this is what we believe. Let us know what you find out. Prices are constantly changing and may be inaccurate.

We have little familiarity with VMS. Recommendations made here should not be construed to be applicable to any operating system other than UNIX. We have often adapted UNIX to these devices in a way that may not be possible with other operating systems.

Finally, note that we have written this document to share the knowledge we have acquired with you. We have written it because we do not have the time to talk to everyone who needs this information. Please do not call us to confirm the information here or to ask questions about our opinions. We would like to hear of your experiences, or learn of mistakes in this document or products that we know nothing about, but do not have time to chat about the information that is given here. We do welcome electronic mail sent to our addresses as shown on the first page.

OVERVIEW

We first discuss components, listing the alternatives we have tried and sometimes a few we haven't, and then discuss system packages. We buy a substantial portion of the equipment we use from vendors other than DEC. The reasons for choosing second vendor equipment are usually some combination of more current technology, lower cost for equivalent equipment or shorter delivery time.

We do not consider devices that have proven unreliable or whose performance we consider inadequate. In addition, there are many devices that we have no experience with. As a general rule, every new peripheral has required a non-trivial amount of leg work to get up to speed. We suggest using only peripherals that have been previously used successfully on *the type of VAX you are configuring* (780 or 750) or demanding a substantial (50-100 percent) discount for being a guinea pig. Be especially careful of UNIBUS† interfaces. Almost every manufacturer of a UNIBUS widget now includes the VAX as a machine on which his device will work. Few of these devices have been tested in this situation. Many of them will not work without substantial modification.

All prices quoted are *undiscounted, quantity one*, unless stated to be otherwise and are accurate to the best of our knowledge at this writing. We usually receive at least an educational discount and sometimes a quantity discount. These typically reduce the list prices from ten to forty percent. Since discounts vary from area to area and prices change frequently, you should always request quotations from local vendors.

System buyers without ready access to an in-house hardware staff should consider carefully the option of buying as much DEC equipment as possible. If you have the money and time required to do this, there are some strong advantages. Our DEC equipment has, in general, proven somewhat more reliable than the equivalent alternate vendor equipment. Time from equipment delivery to

running system is also usually shorter. DEC field service in our area is excellent. Outside service available for non-DEC peripherals is spotty at best.

For smaller installations this option should be carefully considered. It is easier if you can call one party for all your problems, if you can afford it. At Berkeley, we are well past the inventory level where self maintenance begins to pay off even on all DEC systems, so this is not a consideration. One of us (Kridle) manages our local hardware support group.

Unfortunately, the limited selection of configurations currently available sometimes make the all-DEC choice difficult. This is especially true of the smaller configurations as DEC's bottom end peripherals are less satisfactory for UNIX. We say this not just for monetary reasons; functionally and aesthetically we would prefer to have neither the RK07 disk nor the TS11 tape unit in any system we have to deal with.

We recommend getting field service at least on your CPU for the first year. It has paid off for us in the cost of parts alone. You can drop the contract after the engineering changes have tapered off and most of the infant failures have occurred. DEC requires a certain amount of its peripheral equipment on the machine to qualify for field service. We understand that it is company policy not to provide a maintenance contract for a system without a DEC mass storage peripheral. If you intend to purchase a maintenance contract, be certain that your local field service is willing to support at least the DEC equipment you buy.

BANDWIDTH CONSIDERATIONS

Evaluation of the data transfer capacities between the various parts of VAX systems is a complex task that plays a critical part in system configuration. Unfortunately, there is a tremendous amount of misinformation available on this subject and little useful hard data. We have made a few measurements and intend to make more. What we currently know follows.

The 11/780 UNIBUS adapter is the device most frequently shrouded in confusion. DEC documents variously give the bandwidth at between 1.2 MB/sec and 1.5 MB/sec when transferring through a buffered data path. We are not aware of any specifications for the unbuffered data path but have not been able to use it with some devices as slow as 50 KB/sec. One experiment we conducted involved examining the UNIBUS protocol lines with a scope while constantly transferring from a disk drive. We observed that while the drive was transferring at an average rate of about 1.2 MB/sec the UNIBUS was close to one hundred precent busy. This test was conducted on an otherwise idle system. No other devices were active on the UNIBUS and large disk transfers (cylinders) reduced any register set up time to a minimum. We conclude from this that 1.2 MB/sec is the *absolute maximum* transfer rate possible through a 11/780 UNIBUS adapter. Our observations showed that the largest delays while transferring data occurred while the buffered data path was being loaded or unloaded from the SBI. Since the UBA is controlled by a micro sequencer that is also involved in other UBA activities such as processing interrupts, we suspect that on an active UBA this bandwidth may be somewhat reduced.

It is also our conclusion that UBA bandwidth is not an important limitation in most applications. Most modern disk controllers have at least 1536 bytes or three sectors of internal buffering. This means two things: first, they can be designed to never produce *data late* error conditions regardless of the transfer size. Second, they can complete an entire track transfer without losing a

revolution in all but the most adverse circumstances. UNIX rarely makes single transfers larger than a single disk track.

There are troublesome devices that cannot buffer enough data to guarantee that the maximum size record can always be transferred (6250bpi tape drives) or do not buffer an adequate amount of data (RK07 disk controller). To handle these devices UNIX provides a software interlock mechanism that prevents excess UBA contention.

The MASSBUS adapters are specified to have a higher potential bandwidth of 2.5 MB/sec. Since they are selector channels that allow only one device to transfer data at a time, the realized bandwidth is limited to the rate of the fastest device. The fastest devices currently available from DEC for 11/750 systems or 11/780 systems with a single memory controller transfer at 1.3 MB/sec. Large 11/780 systems with two memory controllers and interleaved memory may run RP07 disk drives that then transfer data at 2.2 MB/sec.*

We have measured the average throughput of disks with a maximum transfer rate of 1.2 MB/sec (RM05 equivalent) using three different interfaces on an idle 11/780 system. The interfaces included a DEC MASSBUS adapter, a foreign vendor SBI interface, and a foreign vendor UNIBUS interface. In all three cases the throughput was within a few percent of the maximum rate for the disk drive.

Our conclusion is that for most UNIX applications, the UNIBUS interface is adequate. It is usually equivalent in performance to MASSBUS interfaced devices and less expensive. The long history of foreign vendor UNIBUS interfacing has created a rich and competitive market of devices. If necessary, a second UNIBUS adapter can be added at a cost similar to that of a MASSBUS adapter and is fully supported by UNIX.

A more interesting bandwidth limit may be established by the memory controller. We suspect that the CPU may be slowed considerably by memory contention when two disk channels are being used simultaneously. This should be alleviated by using interleaved memory controllers. We have a second memory controller, not yet installed, and intend to attempt measurements soon.

The appendix to the *VAX Hardware Handbook* titled "System Throughput Considerations" seems to bear out these impressions and should be read carefully by anyone hoping to understand the consequences for VAX applications involving high bandwidth input or output. If we had data intensive applications we would seriously consider the use of RP07 disks (and interleaved memory controllers) because of the resultant higher burst transfer rate; this will be discussed further below.

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* On machines with only one memory controller the RP07 hardware is arranged to transfer at 1.3 MB/sec. It is our understanding that RP07's will work on 11/750's with a single memory controller at 2.2 MB/sec, but RP07s are not currently sold for 11/750s.

MEMORY

All VAXes are sold with some minimum amount of DEC memory adequate to run diagnostics. Additional memory is the lowest risk alternate vendor choice. We buy the remainder of our 780 memory from National Semiconductor or Trendata.** We are currently paying about $5,000 per megabyte. This area is extremely competitive and there are at least 6 possible vendors. By all means, ask for competitive quotes. Assure yourself, however, that you are not the first customer for a new vendor.

Add in memory for the VAX 750 is a newer item and prices are not as low. However, this memory is almost identical to the 11/70 MK11 memory and several vendors have managed to build this product by modifying their previous 11/70 add-in product. Trendata 750 memory is currently listing at $2300 per 258 Kbyte board. A fifteen percent educational discount is available. A substantial GSA discount is also available.

Small quantities (one to two megabytes) are usually available off the shelf from Trendata or National. Large quantities (4 megabytes and up) have taken less than 30 days.

For the 11/780 memory, the RAM chips are socketed, and two replacement chips per board are supplied by both Trendata and National; these are the only two second vendors whose memory we are currently using. You can pull out the board and replace the chip at your leisure. Since single bit errors are corrected this has never involved any unexpected down time for us. There is at least a one year return to factory agreement on the boards, included in the purchase price. Out of warranty repairs are said to typically cost less than $300. We have returned only one board to the plant in about 30 board years.

When purchased from DEC, memory is $19,800 per megabyte in 1 megabyte quantities or $15,950 per megabyte in 2 megabyte quantities for 780s. Maintenance on DEC memory is $231 per megabyte per month with board replacement through field service. The boards are not socketed. Delivery times on memory from DEC have typically been substantially longer than times from second vendors.

If you are going to have more than 4 megabytes of memory to your 780 you will need a CPU expansion cabinet at $4,460 and a second memory controller for $26,600 that includes a second half-megabyte of DEC memory. It is not currently possible to put more than 2 megabytes on a 750†. This reflects both the maximum addressing capacity of the controller, and the lack of space for an additional controller.

DISKS

There are three alternatives for disks. The first is to buy the disk hardware from DEC. The available equipment includes 67M byte removable disks (RM03), 252M byte removable disks (RM05) and 124M byte non-removable disks (RM80), and a new and aggressively priced 504M byte non-removable disk (RP07) that can be made to run at 2.2 MB/sec on 11/780's with interleaved memory.°

** A list of second vendors and their phone numbers is given at the end of the document.
† We have heard that a recent DEC field change order prevents use of more than 1.75 Megabytes of memory on an 11/750.
° Disk sizes shown throughout this document are in bytes of formatted space available.

DEC also sells RK07 cartridge disks that we don't consider a viable option for UNIX for several reasons. They will not work concurrently with other UNIBUS DMA devices because of insufficient buffering (we mitigate this somewhat through software interlocking on the UNIBUS) and they are small and slow. If you get a system with these in it you can sell a drive and keep the other to have a DEC mass storage peripheral for maintenance reasons. It is currently possible to get roughly $7,500 for a single RK07.

The viable DEC disks run on MASSBUS adapters, and are, except for the RM80, other manufacturers' drive hardware with some DEC electronics added. The DEC disks are significantly more expensive than the alternatives from other vendors. The second-vendor UNIBUS controllers use bit-slice technology and microcode, while most of the older DEC controllers use discrete logic. The following summarizes the cost of the drives available from DEC including two packs for each drive where applicable; sizes shown are formatted space available. First drive prices include a MASSBUS adapter.

Type	Size	First	Maint	Add-on	Maint
RM03	67MB	$30,935	$179	$20,935	$147
RM05	256MB	$45,450	$310	$35,450	$240
RM80	124MB	$29,900	$132	$19,900	$100
RP07	504MB	$48,000	$240	$38,000	$180

The second alternative is to get a MASSBUS† look-alike. Systems Industries will sell you a modified 9400 controller and storage module CDC 256MB removable pack drives or Fujitsu 134MB Winchesters. These setups are less expensive than the same capacity from DEC, but are currently available only for 11/780's as far as we know. We currently do not use this equipment at Berkeley but are aware of several satisfied users running UNIX. For disk I/O intensive systems, having the extra disk channels offered by MASSBUS adapters or multiple UNIBUS adapters is a definite advantage. Costs from Systems Industries including two packs per removable media drive are:

Type	Size	First	Maint	Add-on	Maint
CDC 9766	256M	$38,500	$225	$19,400	$166
Fujitsu*	134M	$22,000	$173	$9,500	$114
CDC 9775	576M	$39,900	$226	$28,500	$167

The final alternative, and the one that we prefer for all but the largest 11/780 systems, is to get a UNIBUS storage module disk controller and some storage module drives. We run most of our disks on the UNIBUS, and have had good luck doing so. Each of our VAXes has an Emulex SC21/V controller with one or more Ampex 9300-CD 253MB drives. The Emulex controller is a single card in the

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† DEC considers at least some MASSBUS emulating interfaces to infringe on their hardware patents and are pursuing legal action against selected vendors. We are not clear about the implications of this for users of these devices.

* If you put Fujitsu drives on a Systems Industries controller, the drives normally appear to be multiple RM03's to the system. This causes problems in that the system thinks it can do parallel seeks on drives that actually are pieces of the same drive. Some sites have modified the drivers to alleviate this problem, but these modifications are not part of the standard system. There is also an option to cause the Fujitsu's to appear as single large drives, but the drive type register still says that the drive is an RM03. We are talking to SI about making it possible to discriminate the devices in the software, but this is not yet in the standard release.

UNIBUS box and handles up to 4 storage module drives. We get a better price from Ampex than from CDC, whose 256MB drives seem about equivalent. Emulex and CDC have an agreement for service through CDC organizations of SC21's with CDC drives. We maintain our Ampex drives in house. The Emulex SC-21/V lists for $6,000. Quantity one list price for the Ampex 9300-CD is $14,000. Cables run about $250 per drive. We buy Dysan error free 300MB packs for about $1,000 each (2 for each drive). Thus the total cost for a 253MB drive and its packs is $22,250. Non-discounted CDC prices add about $2,000. Below we show package prices including cables and 2 packs.

Another good storage module drive that is running on VAXes (11/750's) at Bell Laboratories with the SC-21V controller is the Fujitsu 134MB Winchester Drive. We have had extremely good reports on this drive, although we don't have any ourselves. The Emulex storage module packages we suggest are thus:

Type	Size	First	Maint	Add-on	Maint
Fujitsu	134MB	$13,750	???	7,750	???
Ampex	253MB	$22,250	???	$16,000	???
CDC	256MB	$24,250	$300	$18,000	$224

TAPES

We use Emulex TC-11/P UNIBUS tape controllers that list for $3,600 and Kennedy model 9300-3 800/1600 BPI 125 IPS transports at $7,200. You also need a rack to mount the tape drive and cables. An assembled system lists for about $12,000 excluding discounts. The Kennedy transport comes with a 15 month factory warranty. Our distributor exchanges/repairs the cards in the controllers based on a local diagnostic mode in the transport. After the warranty period, card swaps cost about $75. For transport mechanical failures the transport is returned to the factory in Monrovia, California, or we fix it ourselves.

George Goble at Purdue is using a 6250 tape system with UNIX. It includes a Telex 6253 drive (800/1600/6250 BPI) 125 IPS with a TELEX Formatter and an Aviv 1 board UNIBUS interface. The UNIBUS interface has 4KB of buffering, to help with bus latency problems, and it really seems to be necessary. The whole system costs him about $32,000. It emulates a TU10 similarly to the Emulex NRZ/PE controller. 6250 at 125 IPS and uses the entire UBA. UNIBUS access can be arbitrated by the operating system to allow a 6250 BPI tape drive and a disk controller to coexist on one UBA if necessary. N.B.: The driver for this controller/transport combination is not currently included in the standard 4.1bsd system.

Name	Speed	Densities	Cost	Maint	
Kennedy	125ips	800/1600	$12,000	???	
Telex	125ips	800/1600/6250	$33,000	???	(No driver in 4.1bsd)

Our original VAX system came in a package with a DEC TE16 on its own MBA. The TE16 is reliable but slow. The DEC TU45 is faster, but fraught with problems as the high maintenance cost reflects. The DEC TU77 is a good transport, but the auto-loading features don't seem to work well, and it is expensive. Finally, there is a new product from DEC, a 1600/6250bpi 125ips tape drive, the TU78. This is the same transport as the TU77. We do not have a driver for this in the current distribution (4.1bsd), but expect to have one soon. As 6250bpi tapes are

desirable in systems with large amounts of disk storage, we expect that this will be an attractive tape drive to include in systems with large amounts of disk storage.

The UNIBUS tape, the TS11, is included in packages for the 11/750 except for the RK07 package system. It does not have a vacuum column, and is thus hard on tapes. It is a problem to load and seems to be unreliable.

Name	Speed	Densities	Cost	Mtce	
TS11	45ips	1600	$13,398	$75	(Not recommended)
TE16	45ips	800/1600	$22,000	$147	
TU45	75ips	800/1600	$25,424	$265	(Not recommended)
TU77	125ips	800/1600	$30,453	$235	
TU78	125ips	1600/6250	$52,000	$340	(No driver in 4.1bsd)

TERMINAL INTERFACES

With a VAX you get 8 lines of DZ-11 that provide some modem control but are not DMA. We use the Able DH-11 emulator, the DMAX/16, that gives 16 lines of DMA output ports without modem control for $4,500, or with modem control for $5,300. We have been getting about 30 day delivery on the these. We are currently testing new products from both Able and Emulex that have lower costs per port and consume less backplane space and power. We expect to finish evaluating these units soon. The current alternative from DEC is more DZ-11's, that cost $2,050 for 8 additional lines, that can be accommodated in the same distribution panel, then $4,300 for each additional 16 lines.

Both the DZ's and the DH's have input silo's that UNIX can use to reduce interrupt load on input. The DMA output of the DMAX is especially important for graphics applications where high-volume and continuous output occurs.

MODEMS

We buy Vadic modem racks for the system end. Vadic offers modems that can talk both standard 300 baud and also the two commonly used 1200 baud styles: Bell 212 and Vadic. It is handy to have these "triple" or "3-way" modems in your machine.

Here are the list prices of various components:

Chassis	$450	(Provides 16 slots)
Power Supplies	$200	(You can use two for redundancy)
3-way Answer	$850	(Takes 2 slots)
Autodialer	$500	(Takes 1 slots, and need 300 and/or 1200 stuff below)
RS232 to RS466	$500	(Converter for autodialer)
300 Orig/Ans	$450	(Takes 1 slot, for autodialer)
1200 Orig/Ans	$740	(Takes 1 slots, for autodialer)

A rack with 5 3-ways and no auto-dialers would cost about $5,100 and would have 6 free slots for additional modems. A rack containing 5 3-way modems, and a 300 baud and 1200 baud dialer would thus have only one free slot, and would cost about $7,250. This equipment has had some infant failure problems.

The Vadic home-end originate answer 300/1200 modems that can also talk to Bell 212 modems are $750 when purchased with Voice/Data switches, These plug directly into modular phones. We have had trouble with initial reliability on these; about 1/3 don't work when received. We are currently buying Ventel modems for home use and reliability seems improved. They too are about $750. These are only two way, 212 std. for 1200 baud and 103 std. for 300 baud but since we have no vadic only answer modems, this is not a problem for us.

We have heard of a new DEC product in modems: the DF03. It is a 300/1200 baud modem using a chip to do the Bell 212 1200 baud standard. It is attractively priced, the DF03-AA is $950 and a unit that provides auto-calling, the DF03-AC, is $1,350. These have been used successfully by the UNIX group at DEC for some months now. We are hoping to try some of these soon.

PRINTERS

We have been using some Printronix 300 line per minute dot-matrix printers. They do point-plotting at 60 points per inch. They are not outstandingly cheap ($7,000), but are ruggedly built.

The new Data Products B-600-1 is a 600LPM band printer. This sells for $7,500 with controller. Although we don't have one of these, Tom Ferrin at UCSF has been using one for four months and is satisfied.

PLOTTERS

Electrostatic printer/plotters that are capable of 200 dots/inch are usable both as printers and as output devices for *troff*. We have an old model Varian that requires considerable care and feeding; newer models are said to be less of a headache. A new Versatec 11" model sells for about $8,000. The objections to these guys are that the paper tends to be wet sometimes, stinky, and more expensive than line printer ($20 per 1000 sheets). These are high maintenance items as are all heavily used hardcopy output devices we are familiar with.*

LOCAL NETWORK INTERFACES

We are currently getting experience with an Ungermann/Bass NET/ONE local network interface, which uses an Ethernet-technology coaxial network. We are also getting some DMR-11 interfaces from DEC, that allow point-to-point networking at up to 1Mbit/sec. The older DMC-11 interfaces can be made to work at high speeds only by modifying the hardware and should probably be avoided.

We are hoping to learn much more about local network products in the next few months and would like to hear any UNIX user experience with different commercially available devices.

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* Note added in proof: some new laser printers have recently been announced. There are at least two devices now commercially available: one from Canon lists for about $28,000 and comes with either RS232 or DR-11 interfaces, and another we have heard of lists for about $8,000 in small quantities; look in recent DATAMATION issues for details.

SYSTEM PACKAGES

We now present some sample system packages. Each represents a balanced system for timesharing use under UNIX. People often ask us how many users can be supported under UNIX in these configurations. In the absence of specific information about applications to be run this is an unanswerable question. The amount of load presented to the system by different applications varies widely. We mention with each system the count of interactive users typical of our university research environment that could be supported by the system.

We first present systems based on 11/750s and then systems based on 11/780s. With each system we suggest similarly functional systems configured in at least two different ways: first with as much equipment as possible from DEC and second with the best equipment known to us.

Various people have measured the speed of 11/750's and 11/780's and found that the 11/750 executes at roughly 60 percent of the speed of an 11/780. By comparison, an 11/70 runs at roughly 75 percent of the speed of an 11/780 on the same benchmarks, that involve no floating point, no 32 bit arithmetic on the 11/70 and also no system calls. For time sharing UNIX usage we believe that the 11/750 should have better performance than an 11/70. The additional tuning and performance enhancements to the VAX kernel and larger address space of the VAX provide the boost for the 11/750.

The first system we consider is a small 11/750. We are fond of the 11/750, as it is cost effective for small systems. The problems with starting with an 11/750 are that it is not as expandable as the 11/780, and that there is currently no hardware floating point unit for the machine. We present an expansion of the 11/750 into a larger system.

The second base system is a small 11/780. We show how it can be built from a DEC RM80/TU77 package system, and two different ways to build it from a DEC RK07 package using the best equipment that we are aware of, emphasizing either lowest cost or capacity for expansion to a system with high i/o bandwidth.

The small systems we suggest start with a single disk and tape controller and some memory. For time-sharing applications we configure our VAX systems allowing 256k bytes of memory for the kernel and roughly an additional 100k bytes of memory per active user.* Memory is cheap, especially for the 11/780, so we don't skimp on it.

With more than a few users, it is critical that more than one disk arm be present in the system. Thus all but the smallest systems include more than one disk. As the active user count rises, having more than one disk controller is also a good idea. The large system packages include more than one disk controller. For large and i/o intensive systems we recommend the fast new RP07 drive from DEC as it runs at 2.2 MB/sec, twice as fast in burst rate as the other drives; this requires running with interleaved memory.

It is desirable on all UNIX systems to have at least 100MB of disk space so that all the source for the system and all the standard programs may be kept on line with some room for locally developed programs. The amount of space required by user programs varies per installation; we manage to run many of our instructional/research machines using about 300 megabytes of space actively, although slightly more than this would be desirable.

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* These numbers work reasonably well in an environment typical of University work (course work, paper preparation, debugging programs, developing applications for microcomputers, etc.) More demanding applications could require substantially more memory per user.

Our large research machine runs with 1 Gigabyte of disk storage, with 2 disks on a UNIBUS and 2 disks on MASSBUS adapters. The weakest point in this system is that it has only a 45ips TE16 tape drive for backups. For even the smallest systems, 45ips will soon seem slow. We therefore recommend starting with a 125ips 1600bpi tape drive. As full 2400 foot tape reels hold only 30MB at 1600bpi, large systems would be a good idea to include a 6250bpi tape drive.

Finally, in all but the smallest systems we include modems and printers. 300 baud modems are painfully slow, so all our systems include 300/1200 modems. Given an auto-call unit you can hook your machine into a loosely coupled network of UNIX machines called the *uucp* network. As such auto-call units are inexpensive, adding one can be a valuable way of tying into the UNIX community.

VAX 11/750 PACKAGES

We want to put together a small 11/750 system capable of supporting about 8 time-sharing UNIX users, and a larger 11/750 system for roughly 16-24 users. We need a minimum of 100 megabytes of space for the small system and a reasonable tape drive, preferably a 125ips drive so that tape operations can be done in a reasonable amount of time; if the system is to include only non-removable disks, we consider the faster tape system to be important. For the larger system, we wish to add disk space to give the system a minimum of 250 megabytes of space, and have more than one disk arm.

Small system

When buying an 11/750 the most difficult problem is the sales packaging of the systems. DEC currently packages only 3 11/750 systems, and we are not happy with the tape equipment in any of these systems. The small DEC system includes 2 RK07 disk systems. These are not adequate to support our desired configuration, since they supply only 28 megabytes of space each. To build a system from all-DEC equipment we would thus start with the the RM80/TS11 configuration, SV-BXWAA-AA; this lists currently for $120,000, less $5,000 for VAX/VMS license only. The TS11 tape drive is a 45ips 1600bpi only tension arm tape drive, and does not meet all the requirements for our system, but is the only tape drive available from DEC for the 11/750. We would prefer to have a 125ips tape transport but the only 125ips transports available from DEC are far too expensive to be reasonably included in this system, even if DEC sales packaging rules would let you buy them.

You can consider building a system using equipment from vendors other than DEC. You can buy the cheapest currently available packaged configuration, the SV-BXHHA-AA dual RK07 system; this lists for $89,900 less $5,000 for dropping VMS support, or $84,900 list for most UNIX users.* This package represents the most cost effective way for non-OEMs to currently purchase a CPU, although the RK07's are not useful. A single RK07 drive is required for DEC field service. The second drive lists for $12,000, and if you can sell it for $7,500, you can bring the foundation cost down to about $77,400.

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* If you qualify as an OEM, you may be able to buy a bare CPU for about $49,000 list from DEC; we have not been able to buy the naked CPU even given the quantity of hardware we buy from DEC.

To this we would then add:

0.5M Trendata memory	1 MB total	$4,600
Emulex SC-21V/Fujitsu	134 MB	$13,750
Emulex TC-11P/Kennedy 9300	125 ips	$12,000
Total starting from DEC RK07 package		$107,750

Thus, summarizing the possibilities, we can start by buying an RM80/TS11 system; this will give us 124M bytes of disk space and a 45ips tension arm drive for $115,000 list price or we can buy a RK07 system, sell a RK07 drive, and add a Emulex disk controller and a 134M bytes Fujitsu drive and an Emulex tape controller and a 125ips Kennedy tape drive, to a total cost of $107,750.

Medium system.

To expand this basic system to support more users and get additional disk space, we would add additional lines, disk storage, modems and memory. To add this equipment to the small all-DEC system we would add another RM80, another Megabyte of memory and a DZ-11E:

RM80/TS11 base system		$115,000
MS750-AC 1MB memory	2MB total	$19,800
RM80-AA 124MB disk	268MB total	$19,900
DZ11-E 16 lines	24 total	$4,300
Vadic Modems	5 300/1200	$5,100
Data products B-600-1	600lpm	$7,500
All-DEC Medium 11/750 cost		$171,600

To make this system from the RK-07 package using non-DEC equipment we would add the following equipment to the small system:

RK07 base system		$107,750
1M Trendata memory		$9,200
1 134M Fujitsu disk drive		$7,750
Able DMAX	24 lines total	$4,500
Vadic Modems	5 300/1200	$5,100
Data products B-600-1	600lpm	$7,500
Add-on cost		$33,700
Total starting from DEC RK07 package		$141,450

The differences in the hardware functionality between the two medium 11/750 systems are: The DMAX is a DMA device more suitable for high-speed output, while the DZ11 is interrupt per character. The system not all from DEC includes a 125ips vacuum tape drive while the DEC system includes a 45ips tension arm drive. The all-DEC system has a MASSBUS disk drive, on a different bus than the tape. The non-DEC system includes a single RK07.

VAX 11/780 PACKAGES

For a system with more growth possibilities than an 11/750, faster processing (especially floating point), and higher i/o bandwidth, we recommend starting with a small 11/780. Our goal here is to start with a system capable of supporting 8-16 timesharing users and expanding the system to be capable of supporting rougly 24 users. We also consider a large expansion of this system, to a system that might support 32 to 40 terminal users to the exhaustion of available CPU cycles.*

Small system

For our small system we require 100 Megabytes of disk storage and a 125ips 1600bpi tape drive that will be capable of handling file backups if the system is eventually expanded. In our first expansion of this small system, we wish to add to the available space to a minimum of 250 Megabytes of disk storage, acquire at least two disk arms, and add additional terminal lines, a printer and modem equipment for dial-in lines. In a large expansion of this system we include more terminals, an additional disk controller to get at least two separate disk channels, and an additional 500 Megabytes of storage for a minimum of 750 Megabytes.

To build a small system from all DEC equipment, we would start with the RM80/TU77 based system, the SV-AXWBA-CA. This system includes 8 terminal lines, 1 Megabyte of memory, a 124 Megabyte disk drive and a 125ips tape. The system lists for $225,000, and we can save $5,000 by getting a system without VAX/VMS support making the basic all-DEC system list price $220,000. To this we would add .5 Megabyte of memory, the MS780-DB for $13,900, and a floating point accelerator for $10,600 to bring the total all-DEC system price to $244,500.

As we did for the 11/750, we use an RK07 based system for the nucleus of our system built using second-vendor equipment. We start with the SV-AXHHV-CK package consisting of:

11/780 CPU
512K memory
8 lines of DZ-11
LA120 console
2 RK07 Disks and UNIBUS Controller
VAX/VMS license only

This system lists for $138,000. We would immediately sell a RK07 drive. If we get $7,500 for this drive and add a floating point accelerator we get a list price for the equipment from DEC of $141,100.

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* Using systems similar to the largest shown here, in an environment consisting of small student programming some sites have reported running up to 70 interactive users; cpu cycles are the critical resource with this many users.

To form a system with the performance we desire, while minimizing the cost, we make the following package:

RK07 base system		$141,100
1M memory	1.5MB total	$5,000
Emulex SC-21V/Fujitsu 134MB	172MB total	$13,750
Emulex TC-11P/Kennedy 9300	125ips	$12,000
Add-on cost		$32,750
Total starting from DEC RK07 package		$173,850

The list price difference between these two systems is $55,250; much of the additional cost in the all-DEC system is in the two MASSBUS adapters for the RM80 and the TU77. The bandwidth of these adapters is not critical in this small system. Also, the TU77 is an autoloading tape drive, while the Kennedy 9300 is not. We do not consider these differences significant.

To form a system with the emphasis on handling of data-intensive applications, and to emphasize total growth of the system, we would add an REP07-AA 504MB disk drive and MASSBUS controller to the basic system instead of adding the Emulex SC-21V and Fujitsu drive. To do this, however, we must expand the physical packaging of the cpu package that we based the system on.

We want to add another MASSBUS adapter that there is no space in the CPU cabinet for. There are two possible ways to solve this problem. The first is to rearrange/upgrade the CPU by removing the built in UNIBUS backplane and adding an extender cabinet buying the component parts individually. The second involves purchasing these same parts in an *Upgrade Kit* from DEC. This kit and its component parts, as we are aware of them, are described below:

DEC Part No.	Description	DEC List
H9602-DF	UNIBUS Expander Cab.	$3,360
BA11-KE	UNIBUS Expansion Mounting Box	$3,400
DD11-DK	9 Slot UNIBUS Backplane	$900
	Misc. Cables	~$500
Components Total		$8,160
H9604-BA	DEC Upgrade Kit	$25,000
Unaccounted for Cost		$16,840

Many phone calls to DEC have not produced any explanation of the unaccounted for $16,840 or any reason that you should not simply buy the component parts. On the other hand, our sales representative will not *guarantee* that a system configured with separately purchased parts will work. Our reluctant conclusion is that the missing $16,840 is part of DEC's marketing strategy aimed at discouraging building up large systems from an inexpensive base.

We are planning to build two systems this summer using the component parts hereafter referred to as the *Berkeley Upgrade Kit*. Since we have not yet done this and cannot *guarantee* they will work, you should add the $16,840 cost to these parts to be most conservative about the system package we are suggesting.

Thus to form a small system emphasizing expansion we add:

RK07 base system		$141,100
Berkeley upgrade kit		$8,160
1M memory	1.5MB total	$5,000
DEC REP07-AA	504MB total	$48,000
Emulex TC-11P/Kennedy 9300	125ips	$12,000
Add-on cost		$73,160
Total starting from DEC RK07 package		$214,260

Medium system

To expand this basic system to support more users and get additional disk space, we would add additional lines, disk storage, modems and memory. To add this equipment to the small all-DEC system we would add another RM80, another Megabyte of memory and a DZ-11E:

RM80/TU77 base system		$244,500
MS780-DC 1 Megabyte memory	2.5MB total	$19,800
RM80-AA 124 Megabyte disk	248MB total	$19,900
DZ11-E 16 lines	24 lines total	$4,300
Vadic Modems	5 300/1200	$5,100
Data products B-600-1	600lpm	$7,500
All-DEC Medium 11/780 cost		$301,100

To make this system from the package using inexpensive non-DEC equipment we would add the following equipment to that small system:

RK07 derived base system		$173,850
1M memory	2.5MB total	$5,000
Fujitsu 134MB disk	296MB total	$7,750
Able DH/DM	24 lines total	$4,500
Vadic Modems	5 300/1200	$5,100
Data products B-600-1	600lpm	$7,500
Inexpensive medium 11/780		$203,700

The differences in the hardware functionality between the two systems are:

1) The DH/DM is a DMA device more suitable for high-speed output, while the DZ11 is interrupt per character.
2) The tape drive in the all-DEC system is autoloading.
3) The DEC system has MASSBUS disks and tapes, while the non-DEC system has UNIBUS peripherals. We do not consider this to be a serious problem for a system of the size considered here.

Finally, to put together a system with maximum growth possibilities we would take our small growth system and add an RP07-AA instead of a Fujitsu drive; giving the following breakdown:

RK07 derived base system		$214,260
1M memory	2.5MB total	$5,000
RP07-AA 504 MB disk	1036MB total	$38,000
Able DH/DM	24 lines total	$4,500
Vadic Modems	5 300/1200	$5,180
Data products B-600-1	600lpm	$7,500
Growth medium 11/780		$274,360

Large system

To build a large system from the medium system we add additional memory and more disk storage.

To the all-DEC system we would add an RP07 504 Megabyte disk drive, 1 Megabyte of additional memory, and 16 additional terminal lines:

Medium RM80/TU77 system		$301,100
MS750-DC 1 MB memory	3.5MB total	$19,800
RP07-AA 504 MB disk	752MB total	$38,000
DZ11-E 16 lines	40 total	$4,300
All-DEC Large 11/780 cost		$363,200

We would put the RP07 disk on the same MASSBUS adapter as the TU77 tape drive, leaving the two RM80 disks on the other MASSBUS adapter.

To build a similar system from our inexpensive medium system we can either add an RP07 to the system, or add another UNIBUS adapter and get more redundancy by putting in another Emulex disk controller and two more drives; if either UNIBUS or disk controller were to fail, this system could run all disks on one controller on one UNIBUS.

To build a UNIBUS based large system we add an upgrade kit, an additional UNIBUS adapter, an additional megabyte of memory, a second Emulex disk controller, two 253MB AMPEX 9300 drives, and an additional 16 terminal lines:

Medium inexpensive system		$203,700
Berkeley Upgrade Kit		$8,160
Additional UBA	2 total	$12,300
1MB Memory	3.5MB total	$5,000
Emulex SC-21V/Ampex 9300-CD		$22,250
Ampex 9300-CD(add on)	802MB total	$16,000
Able DMAX	40 lines total	$4,500
Total large UNIBUS system cost		$271,510

To make the large VAX system adding a RP07 and a MASSBUS adapter instead of two UNIBUS adapters, we add an REP07-AA 504MB disk drive and MASSBUS adapter instead of the additional UBA, Emulex controller and AMPEX disk.

Medium inexpensive system		$203,700
Berkeley Upgrade Kit		$8,160
1 MB Memory	3.5 MB total	$5,000
REP07-AA 504 MB disk	800MB total	$48,000
Able DMAX	40 lines total	$4,500
Total large UBA/MBA system		$269,360

Both of these large systems include multiple disk controllers: in the all-DEC system both MASSBUS adapters are acting as disk controllers; in the all UNIBUS system, there are disk controllers on both UNIBUSes. In the UNIBUS/MASSBUS system there are disks on both. The differences between the all-DEC and the not all-DEC systems remain: DMA terminal i/o is lacking in the all-DEC system, and the systems that are not all-DEC have removable media: the RK07 and also the Ampex storage modules in the all UNIBUS system.

It may be desirable in a system of this size to have a 6250bpi tape drive. We have a system with 1 Gigabyte of online disk storage that has only a 45ips 1600bpi tape drive to do backups, and find them painful. With a 125ips drive we think that the backups would be tolerable, and given our lack of experience with the 6250bpi drives do not include one here.

With a system as large as these it may be desirable to have a second memory controller and to interleave memory. We have a second memory controller on the premises and intend to experiment with this soon. To run an RP07 at full speed a second memory controller is necessary. Systems with two memory controllers and interleaved memory are discussed next, in examining VAX systems for data intensive applications.

Thus we consider our final two systems, that flesh out the growth versions of the system. First we add memory and more terminals to build a system comparable to the other large systems, and a 6250bpi DEC TU78 controller for two reasons: to provide high speed backup, and to put a RP07 on its MASSBUS, since we as yet have only one disk channel.*

We form this system as follows:

Medium expansion system		$274,360
1 MB Memory	3.5 MB total	$5,000
TEU78-AA Tape	6250bpi	$52,000
Able DMAX	40 lines total	$4,500
Total large expansion system		$335,860

Recall that this system has two tape controllers and still has an RK07 controller and single drive; these could be sold now, since the RK07 was kept only for maintenance reasons and the the tape drive is replaced by the TU78.

* Note that there is no TU78 driver in 4.1bsd, although we expect to have one reasonably soon.

Finally, to expand this system to its full capacity and to make it possible to run the RP07's at 2.2 MB/sec, we add an additional memory controller to the system. We also flush out the system to the full 8MB of memory:

Large expansion system		$335,860
MS780CC mem ctlr	.5MB	$26,600
H9602-HA expander cab		$4,460
4 MB Memory	8 MB total	$20,000
Total full expansion system		$386,920

SYSTEM SUMMARY

In the summary that follows, "All-DEC" means that all mass storage, memory and terminal interface devices are DEC supplied; all systems include second vendor modems and printers.

Type	CPU	Mem	Disk	Tty	Tape	Modems	Lpr	Price	Ratio	"All DEC?"
Small	750	1M	124M	8	45ips	None	No	$115,000	1.00	Yes
Small	750	1M	172M	8	125ips	None	No	$107,750	0.94	No
Med	750	2M	248M	24	45ips	5	Yes	$171,600	1.00	Yes
Med	750	2M	306M	24	125ips	5	Yes	$141,800	0.83	No
Small	780	1.5M	124M	8	125ips	None	No	$244,500	1.00	Yes
Small	780	1.5M	172M	8	125ips	None	No	$173,850	0.71	No
Small	780	1.5M	532M	8	125ips	None	No	$214,260	0.88	No
Med	780	2.5M	248M	24	125ips	5	Yes	$301,100	1.00	Yes
Med	780	2.5M	306M	24	125ips	5	Yes	$203,700	0.68	No
Med	780	2.5M	1032M	24	125ips	5	Yes	$274,360	0.90	No
Large	780	3.5M	752M	40	125ips	5	Yes	$363,200	1.00	Yes
Large	780	3.5M	802M	40	125ips	5	Yes	$271,910	0.77	No
Large	780	3.5M	1032M	40	2*125ips	5	Yes	$335,860	0.92	No
Large	780	8M	1032M	40	2*125ips	5	Yes	$386,920	1.06	No

CONCLUSIONS

We have presented sample VAX systems over a wide performance range using both all-DEC and the best available second vendor equipment, emphasizing independently minimal cost and maximal expandability. Use this information wisely; price shouldn't always be the bottom line.

Consider the all-DEC system if you can afford it. If not, the second-vendor equipment in the packages here is all thought to work well on VAX hardware. You can reliably operate such a system if you can get maintenance for such equipment in-house, or through a organization associated with the vendor, or can stock some spares for non-redundant equipment.

VENDOR REFERENCES

Manufacturer	Product	Phone	Vendor contact
Able	Async. Mux	(714) 979-7030	Able Computer (Norm Kiefer)
Ampex	Disks	(408) 255-4800	Ampex (Jess Clark)
Aviv	Tape controllers	(617) 933-1165	John Connolly
CDC	Disks	(415) 820-2933	Eakins Associates (Joe Voelker)
Data Products	Printers	(415) 948-8961	MQI Associates (Avery Blake)
Dysan	Disk Packs	(408) 730-2145	Dysan (Sandy Foss)
Emulex	Controllers	(415) 820-2933	Eakins Associates (Joe Voelker)
Fujitsu	Disks	(415) 820-2933	Eakins Associates (Joe Voelker)
Kennedy	Tape Transports	(408) 245-9291	Electronic Marketing Specialists
National	Memory	(800) 538-8514	Don Johnson
Printronix	Printers	(408) 245-4392	Group III Electronics (Paul McCann)
Systems Ind.	Storage Systems	(408) 732-1650	John Leavitt
Trendata	Memory	(714) 540-3605	Trendata (Mike Jacobs)
Vadic	Modems	(408) 727-6491	Moxon Electronics (Lee Berlind)
Varian	Plotters	(408) 733-2900	(Ted Downs)
Ventel	Modems	(408) 279-8711	Backus Data Systems (Jeff Masi)
Versatec	Plotters	(408) 985-5810	(Jim Muszalski)